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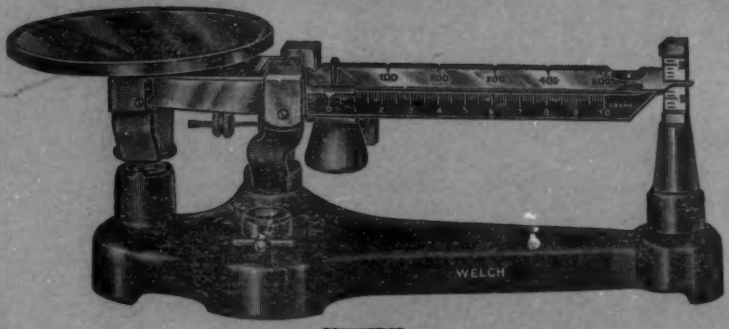

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Moral Attitudes in General Science

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ALL SUBJECTS HAVE A MORAL ASPECT.

Every subject taught in the public schools has some moral values.[1] It is a question of evaluation in the mind of the teacher. How can moral attitudes[2] be developed in a general science course?

The teacher might be continually asking such questions as these: What is in the material of today's lesson that would contribute toward the achievement of character? What particular ethical situations grow naturally out of the subject matter? Is it my business to teach facts only or better still to interpret these facts, showing their worth and meaning? What will help boys and girls to live together, *today*, with a better appreciation of each others worth? How can one be made to feel at home in the world?

THE AIM OF THE TEACHER MUST BE SPECIFIC.

Character is something to be achieved and not to be superimposed. What are the ends or goals we are attempting to have the pupils achieve? One needs to be specific at this point. Do children break open lockers and steal from each other in the public schools? If so, can we shoot *hard* enough and *specific* enough at the target of honesty, with bullets made of science material, to bring about a change of attitude in the

1 (a) Cope—Education for Democracy, Chap. XIII.
(b) "The Spiritual Significance of Mathematics," by Cassius J. Keyser, Ph.D., Professor of Mathematics, Columbia University. Religious Education, Dec. 1911.
(c) "The Message of Mathematics to Natural and Rational Theology," by Professor Keyser. Hibbert Journal, Vol. VII, Jan. and April, 1909.

2 Attitude is used in the sense of "mind set." "We do not develop attitudes and ideals. We develop an attitude toward ideals."
(a) Charters—The Teaching of Ideals, page 34.

mind of the pupil? Why do children mutilate school property? Do boys throw stones at lamps in the parks or write obscene language on public property If so, how can one create an atmosphere from the gleanings of general science that will stimulate the pupil to a new appreciation of property values? Do the members of your class appreciate a sunset or see the beauty in a landscape? Can one select from the whole range of natural science certain definite situations that will reveal to the pupil, without moralizing, the finer values of life? Probably, character is to be caught, even more than directly taught.

DIRECT AND INDIRECT METHODS.

However, there are two ways in which we may attempt to teach morals. One may be characterized as the direct method and the other as the indirect method. "The direct method consists in telling children what is right and what is wrong or how to act."[3] A course in morals is made the direct subject of instruction and attempts are made to secure good conduct by exhortation and emotional pressure. Probably, its greatest weakness is discussing character in the abstract without providing any concrete occasion for exercising it.

The indirect method is the more hopeful, although we need both. One of the most skilful ways to teach morals is by suggestion. The most important factor in the situation is the personality of the teacher. The character and moral tone of the teacher is unconsciously imbibed by the pupils. Often morals may be best taught as concomitants, as by-products. Even at best moral teaching seems elusive, intangible and escapable.

SIMULTANEOUS EFFORT.

It seems evident that if all teachers would train their guns simultaneously upon a given goal much more would be accomplished than by the hap-hazard method so often in vogue. I have a lingering feeling that all teachers should, to some extent, teach morals, just as many teachers make it their business to be interested in the English and health of their pupils.

LEADERSHIP.

The leadership of tomorrow is in the school of today. We

3 Coe—A Social Theory of Religious Education, page 191.

are glad to invest in the education of youth because we believe in the possibility of determining, through them, the character of tomorrow.

Field of General Science.

Does general science offer any opportunity for contributing its share toward creating ideals to which youth may "hitch their wagons"? I am thinking now of the *whole* realm of natural science, as the name general indicates, without any lines of demarcation that would set it off into separate fields, also of boys and girls in about their middle teens, an age full of fruitful possibilities for character building.

Can Sincerity be Taught?

Truth-telling is a very valuable asset, but before one can tell the truth it is necessary to have a truth to tell. Every bit of truth is so valuable that we cannot be too careful in collecting and preserving it. Millions of dollars are spent in scientific research of the most painstaking kind to discover some nugget of truth such as how to combat yellow fever, infantile paralysis or cancer. Thousands of dollars are spent in sending astronomers to distant parts of the earth with the most elaborate apparatus, all for a few seconds or minutes of observation that they may come a little more nearly to telling us the truth about the sun. A cloudy day may render the expedition useless. Think of the expeditions to the North Pole, the South Pole, the interior of Africa and South America and more recently the crossing of the Atlantic and Pacific Oceans by the airplane, and then one realizes how adventurous has been the human spirit in the conquest of truth. What men are willing to sacrifice their lives, if necessary, to discover, boys and girls ought to be willing to learn and appreciate. If a man spends a life-time in studying snowflakes, as one has done, he will be better able to tell the truth about them than you or I who have made no such study, and yet how carelessly we often handle the truth.

Archimedes.

Still further, truth-telling may be enhanced and reinforced by teaching children something of the "scientific process." This process consists of observation, experiment and calculation. It uses the inductive method and is free from authority. This

process may be illustrated by the method which Archimedes used for solving the problem which Hero, the tyrant of Syracuse, had placed before him. "The problem was to determine how much silver there was in a crown supposed to have been made of pure gold. One day while floating in the swimming pool of the public baths of Syracuse, Archimedes suddenly thought of a solution. The thought occurred to him that floating is nothing more than balancing the weight of the body against the weight of the displaced water. That is to say, the weight of a body when submerged in water will be less than its weight in air, and the difference will be equal to the weight of the displaced column of water. If nature's language, which she addressed to Archimedes, is correctly interpreted by this thought, then Hero's problem is easily solved. . . . Yes, it was the discovery of a new concept, the concept of "fluid pressure." He abstracted from the language of nature this new concept and located its position in the logic of nature. By logic of nature is meant the physical operation implied in the concept "fluid pressure," which makes floating equivalent to balancing the weight of the floating body against the weight of the displaced volume of water. The original observation which Archimedes made while floating in the swimming pool of the baths of Syracuse, his experiment of weighing the crown when submerged, and his calculation for the purpose of finding out the proportions of gold and silver in the crown, are the three separate steps in the scientific method of inquiry which he employed.[4] This kind of training has not only scientific value but ethical value by way of suggestion.

Another value of science is that it teaches respect for law. It is but a short step from the concept of law as a fact universal in the physical world, to the recognition of the value of orderliness in the realm of human behavior. The law of gravitation and the laws of health are freighted with suggestions of ethical content.

One of the most outstanding proofs of the orderliness of the Universe is the fact that Neptune was discovered mathematically before it was located telescopically. The starry sky has been found to be "crystallized mathematics," and so far as we know at present is held in the grip of unchangeable law

4 Michael Pupin—The New Reformation, pages 5, 6 and 7.

and order reigns supreme. The Universe has been cast in a mathematical mold.

Property Values.

The observance of law is necessary that life and property may be conserved. As you are driving along over a brick paved road, did you ever stop to think that every brick over which you so rapidly pass represent thought—thought in producing the brick and thought in laying each one on the road bed. Think how much of human value is tied up in just such a simple enterprise.

And again, how many scientific principles and how much thought in the way of racial experience is represented in the building of the Terminal Tower.[5] All these represent values—values that must be conserved and appreciated. "Architecture is frozen music."

All the property about us, lands, houses, skyscrapers, public buildings, railroads, telegraph and telephone lines, automobiles and the rest, which represent the scientific heritage of the race, will have passed into other hands and under the control of other minds, in a generation from now. Can we so blend the moral and the scientific heritage of the race so that these accumulated treasures will be safeguarded by altruistic minds and lofty ideals?

Sex Approach.

Who has a better approach to the sex question than the science teacher? The evolution of sex by the biological approach is certainly one of the most effective and desirable methods of teaching what both the church and home have failed to do.

Vicarious Suffering.

In the vegetable world, the law of vicarious sacrifice is everywhere at work. The seed is placed in the ground; the first process which takes place within it is one of decomposition. The seed dies to release its life to others and succeeding generations. Hugh MacMillan puts it in this way: "All nature is deciduous. The branch is sacrificed that the blossom may be produced; the blossom falls that the fruit may be formed; the fruit drops that the seed may grow."

Everywhere in nature we see vicarious sacrifice at work.

5 Cleveland's new Union Depot.

From the lowest to the highest forms of life this law applies and often the life of the young is sustained at the sacrifice of the mother. Nature sets the great example and mankind must follow to realize its highest good. The world can get on only by suffering. It is only because the innocent have suffered for the guilty and the strong have sacrificed themselves for the weak and the righteous have borne the burden of the wicked that civilization has become possible. The great heroes and heroines of the world are those who suffer vicariously. The boy who rescues another boy from drowning at the expense of his own life; the girl who carries her baby sister out of her burning home at the cost of burns which mark her for life; the man who in a moment of danger allows women and children to pass first to a place of safety at the sacrifice of his own life, as on board the Titanic; these have all suffered vicariously. Amundsen gave his life to rescue Nobile, who was his bitter critic. It is only because parents are willing to sacrifice for their children, and teachers are willing to bear the ignorance of their pupils, and philanthropists are willing to be patient with the ingratitude of the people they wish to help, and patriots are willing to lay down their lives for their country that humanity makes progress. This nation was born through vicarious suffering, and it was preserved in the days of Lincoln by the same sort of suffering. In the World War men over fifty had so shaped national and international affairs that millions of men under thirty were obliged to die. When men give up their lives for others, their sacrifice becomes a form of life. "They rule men's spirits from their urns."

Modern science has released titanic forces that need to be put under ethical control. Science has both relieved suffering and increased it. It has greatly increased the range of vicarious suffering in case of war. In modern warfare, the suffering of the innocent has been greatly increased. "It is singular," says Dr. Charles E. Jefferson, "that all of the modern instruments of war are blind. A howitzer *cannot* see even twenty miles, much less can it see at a distance of eighty miles. The submarine cannot see. It cannot discriminate between belligerent and non-belligerent on the high seas. The airplane is blind. It cannot see the difference between a hospital and an arsenal at the height of two miles. An asphyxiating gas is as

blind as Samson in the mill at Gaza. Science has put out the eyes of war; and its eyes being out, war is more cruel than ever. In olden times an effort was made to spare the innocent. They can be spared no longer. The innocent and the guilty must perish together. In olden times it was only a small fraction of the nation which fought. It is now necessary that the entire nation shall be mobilized. Victory depends as much upon the men and women behind the lines as upon the men in the trenches, and therefore the burdens of war fall upon all." The church and other agencies have long attempted to do away with war, may not the public school take a hand at it by showing that scientific values must be put under ethical control?

Science knows no creed. It speaks an international language. It clasps hands around the world, as, for instance, in the Nobel prizes. Think of four men representing four nationalities, each of whom has contributed a word to the English language pertaining to electricity: Ohm, a German; Watt, an Englishman; Ampere, a Frenchman; and Volt, an Italian. Why can we not capitalize some such ideas as these to promote international peace?

Purpose.

Does the universe have design and purpose? Is it a fit place in which to live? This might be a very different world if the axis of the earth were perpendicular to the plane of its orbit instead of being inclined 23½ degrees. Did it just happen that there is a moon to light our way at night? Is it a mere chance? Is there a cosmic intelligence?

Consider the quaint partnership of the crocodile bird and the crocodile. The bird is benefited because it eats leeches and other parasites which it finds about the crocodile's back and mouth. The crocodile is benefited because the bird is very wary and flies away with loud cries when any danger threatens. How do you account for this mutual interdependence?

The egg-tooth grows on the tip of the bill of a young bird while still in the shell. This egg-tooth is made of hardened horn and lime and is a slight projection on the bill of bird made for a very definite purpose. When the bird is about to be hatched he thrusts his beak into the air-chamber which has formed at the broad end of the egg. Thus he gets his first breath

of air, which rushes down his nostrils, and he is so thrilled with life that he pecks vigorously against the walls of his enclosed chamber, which bursts asunder and he steps out into a new world. What if that egg-tooth were not there or did not come on time? But it always does, and what is more remarkable the bird has use for it only on this one extremely important occasion, for in a little while it disappears. Is not this purpose and intelligence carried to the limit? The universe is an egg shell of precisely this kind. The tooth is always there. The shell breaks on time. The new life comes forth into an environment fitted for it.

The universe is filled with these examples of adaptations: the unique expansion of water at or just before the freezing point, preventing our rivers and lakes from freezing solid in winter, which would destroy all marine life; for scientists tell us there is more marine than land life—or think of the warm fur of the polar bear or the sharp tooth of the tiger.

The pupil ought to be shown as well that there are maladjustments also in the world about us. Why does nature produce a bountiful peach crop and then destroy it by a hail storm? How do you account for the migrating instinct of the birds and then the late storms which kill them by the thousands? Is not this, at least, a seeming inconsistency?

We are worshipping now at the shrine of biology. I conceive of evolution not so much as an unfoldment process but rather as a movement in the creation of new values. It seems more like the work of an artist picturing ideals and then striving to realize them. This is very suggestive of moral values. It teaches that nothing is finished or perfect and never will be. One of the greatest accomplishments of the human mind is that it can always conceive of something better than now exists. The Golden Age is ahead. Faith and optimism must ever be kept alive in the minds of a progressive people.

"We get at the meaning of the peach tree, not by examining the root, but by eating the peach. The thing which comes of it shows what the whole tree is. It's not peach merely at the tip of the branch where the peach grows. It's peach all through —sap and bark and root, and heart and all, all peach. That's the way man has grown on the universe. He's the flower of it. The whole process, beginning away back at the star dust,

has culminated in him. On the same principle the highest in man is the spiritual life, his faith, his love, his aspiration after a higher good, his divine discontent, his art, his literature, his religion. That highest product of his life shows what he is. The ultimate meaning, therefore, of this whole process of evolution is spiritual life. Goodness, piety, love, are no human inventions, no late discovery, no frail drawing of a finite breath, no strangers in an alien world. They are the meaning of the whole great process. The essence of the universe is a purpose, a hope, a faith, a spiritual life. It is a spiritual universe."[6]

Conservation.

A tree is a wonderful thing. It takes more than a thousand years to grow some kind of trees. Nevertheless, a tree that requires a thousand years to grow may be destroyed by man in one brief hour. What would possess a man to kill a tree unless it were for some very worthy purpose? One cannot help but cry out loud when he sees the forests destroyed. We are cutting timber three times as fast as it grows. This is a habit that has become only too common in America, and generations yet unborn will rise up to curse us when they awaken to the nakedness of the land where great forests once abounded. Have the class read Joyce Kilmer's and Henry Van Dyke's poems concerning the wonder of trees.

We have come to see more clearly than ever that we cannot draw continually upon our resources, such as coal mines, oil wells, forest, park reservations and soils without injuring those who will follow us. Conservation applies not only to material resources but to racial and character values, to physical and mental health. Our posterity have a right to expect the very best heritage that we are capable of passing on to them. We can rob them in many ways, by the excessive use of narcotics, by sexual irregularities, by overeating and undersleeping, by living a life of luxury and leisure without any content and by being less than our better selves suggest. We seem to take rather seriously the command, "Thou shalt not steal"; but do we realize how many ways there are of stealing? We can steal the physical resources of our children and our grand-

6 "Religion in the Thought of Today," by Carl Patton, page 37.

children, but we can also steal the *social* and *spiritual* heritage which is theirs. Every man now and in succeeding generations has the right to an opportunity to exercise his powers and develop his personality. Character values come first, and if these are rightly propagated all other values and conservations will be taken care of.

OPEN-MINDEDNESS.

Why is it that most people give such a ready welcome to new scientific discoveries and inventions and have so little concern, even indifference and sometimes organized opposition, for new advances in the social and spiritual realms? We are eagerly looking forward to the next secret that the scientist may rescue from the clutches of the unknown. How readily we accept the automobile, the radio and the airplane. How slow we are to introduce the short ballot, the new prayer book, the revised creed the practice of eugenics or to accept the League of Nations or the World Court. Progress is held up by a sense of sacredness. Our institutions and social life are slowed up by this tendency to worship the past. No one would think for a moment that a bicycle was so sacred he could not have an automobile, or that a candle precluded the possession of an electric light. When science wins a victory it is usually at the expense of discarding some cherished ideas held by many scientists who are among the first to rejoice when the darkness is illuminated by some frontier thinker.

Human institutions tend to keep on living after their usefulness is ended. Reform organizations and political parties, for instance, should be periodically examined to see whether they are still doing the work for which they were originally designed, or doing any useful work or doing it as well as it could be done by other institutions which might be put in its place. How quickly we scrap our old machinery to replace it by new and more efficient apparatus! Nature carries on this process in the plant and animal world by the survival of the fittest. Can this weeding-out process be carried on so thoroughly by man in relation to his institutions for in it are survival values that mean progress? "The dust of controversy —what is it, but the falsehood flying off"? There is something of great ethical value in this forward outlook upon life—a belief that man can change his environment by altering his

institutions and that a better day is ever dawning upon him. Which most influences today, yesterday or tomorrow? Does humanity move forward by a push or a pull?

A Sense of Wonder.

We need to cultivate a new sense of wonder that we may escape the routine and commonplace. The teaching of astronomy, in particular, furnishes material for this sort of thing. Ask questions such as these of boys and girls: What is space? What becomes of the hole in a doughnut when you eat the doughnut? Where does the sky-line end? Do you have a sense of far horizons? What is time? Does the clock tell what time is or does it merely measure it? What do you mean when you say you are so many years old?

Professor Eddington is quoted as saying that if all the "hollow spaces" which separate the atoms were eliminated from the body of Gene Tunney, world's heavyweight champion so that all the protons or nuclei and the negative electrons in his body actually touched, he would be so small that it would be necessary to use a magnifying glass to see him. Which has contributed the more to the welfare of mankind, the microscope or the telescope? Which has aroused the greater sense of wonder?

Why not wonder at the common things beneath your feet? Let the geologist tell the story of the pebble. He tells you that it is water-worn, although no water is near, and that it was fused under great pressure millions of years ago, and that it must have traveled a long distance, moving on the bosom of an ancient river to what is now a shrunken sea. If the pebble could speak, how wonderful would be its story!

Think of the contemptible earthworm that lies across your pathway. They make way for plant roots and rain drops. There are probably from 50,000 to 500,000 of these worms in a single acre and they often pass as much as ten tons of soil, per acre, through their bodies in a single year, and they may cover the earth at the rate of three inches in fifteen years.

Although these worms have no visible ears, they are aware of the light tread of a hungry blackbird. The most remarkable thing about them is that they can grow a new head or a new tail. Moles sometimes make a collection of decapitated earthworms as a source of food to draw upon in winter. Being

headless, they cannot crawl away yet they remain fresh food, for the head will not renew itself at a low temperature.

Does not knowledge of this sort create a new sense of wonder and reverence? Think of the earthquake, the tornado and the cataract. Shall I not take off my hat and maybe my shoes in the presence of these great titanic forces that toss man about as if he were a cork upon the ocean of time? Science will never kill wonder but will always serve to increase it. The fact is that science never ultimately explains anything but only pushes the mystery further back into the realm of the unknown. Our great grandfathers wondered at the lightning, we wonder at electricity.

TEACHING OF SCIENCE THROUGH BIOGRAPHY.

A great deal of general science might be taught biographically. It should be made to focus about such personalities as Edison, Burbank, Newton, Galileo, Morse, Marconi, Lindbergh, Byrd, Amundsen and a host of others. In developing ideals, the learner is influenced by seeing great scientists in action. Nearly all great religions center about some personality and in the political world, the candidate is more to be reckoned with than the platform. Can we not build our science teaching to some extent around the creative thinkers in that field?

APPRECIATION.

Do you appreciate a sunset? We need the refining influence of its quiet, unsurpassed beauty. You can't have enmity and bitterness in your soul with beauty washing it out. "To watch the sun creep through mysterious clouds, dodging the towering tops of the mountains, playing hide-and-seek with the forces of the dying day and the coming night—how the soul is soothed and the heart bathed clean!"[7]

Does the rainbow have a meaning for you? Do you take the beauty out of a rainbow by reducing it to prismatic colors? The size of the rainbow is uplifting. It spans the world. It gives a hint of the great thoughts and wide plans of the universe. "We are like rainbows," Coleridge said, "made up of reflected splendour and our own tears." A rainbow has beauty but no utility. Is beauty its own excuse for being? Is

7 George Mathew Adams.

the color of a billiard ball as *real* as its size, weight and elasticity?

Is your new motor car merely a piece of mechanism or is it a thing of beauty as well? Do you get a sense of satisfaction from meditation upon its graceful curves, and its fine gloss and its correct proportions? Can you sense the rhythm in your automobile? Is rhythm a form of beauty? It is said that musicians are especially sought for as aviators because they can readily sense the rhythm of the airplane.

Does the study of shadows suggest any moral possibilities? Take the shadows out of any picture and the picture is spoiled. Take the shadows out of a landscape and it is flat and insipid. Why is it that noon is the least part of the day? Prose writers may talk of noon, but poets hardly ever do. There is nothing poetic in the noon time. The most musical parts of the day are the morning and evening. The poets sing of the morning and evening, and the reason they sing of the morning and evening is because they are beautiful; and the reason they are beautiful is because they are the times of shadows. A shadow comes as near being nothing as almost anything one can imagine. How much does a shadow weigh? Are the imponderables as real as the ponderables? Is a man's personality as *real* as his clothes?

Did you ever study the shadows cast by the moon, through the tree tops, on the pavement? The moon has a wonderful fashion of turning pavements into silver and using the leaves of the trees as so many patterns with which to embroider beautiful figures and to cast a spell of charm over the observer.

The night is but a great caressing shadow that comes to relieve the glare of the day. The evening, for friends, books, meditation, and a drive or a talk, the night for refreshing sleep.

I believe some of these suggestions and analogies will bear fruit. They will mellow and ripen with the years.

Some Recent Tendencies in Teaching Procedures for General Science[1]

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The assignment for this particular paper was that of summarizing the recent developments in teaching procedures for general science. On the surface, this seems easy. Actually, it presents two serious difficulties. The chairman has suggested that the paper be limited to the very new developments of the past year. If I could put the interpretation upon the term, recent, that was put upon the term, modern, by my old professor of English in his course in Modern English Prose, when he limited the work to the writings of Lamb, DeQuincey and Burke, certain definite trends might be shown. If developments in teaching procedures are limited to the present year, this paper is finished before it is begun. Teaching procedures grow and evolve. Each seeming new type of teaching has roots running into educational philosophies, experimentation, empirical trial and error, and common practice running for many years, sometimes for generations. This paper cannot present procedures that were born yesterday, proved today and to be used tomorrow. It must be concerned with things which have been growing for some time, some of them unproved, some still in embryo, and some sufficiently verified to form the basis of the best and most advanced current practice.

The second difficulty to be met in describing trends in teaching procedures lies in proving up on the statements. Descriptions of trends tend to become predictions. Such predictions with reference to teaching become predictions of the behavior of groups of people, the science teachers of the country, subject to a wide variety of influences. Some of the same difficulties are met that are involved in noting political or economic trends. After all, who knows? There are many conflicting currents. The most recent and radical types exist side by side with mediæval and retro-active practices, sometimes in the same school and once in a while in the hands of the same teacher. There

1 Address before General Science Section, Central Association of Science and Mathematics Teachers, Chicago, Illinois, November 30, 1928.

is no attempt at scientific prediction in this paper. The author has merely placed himself, for the time being, in the guise of a trained observer. Ideas of tendencies have been gained from current reading, observations of practice, from conversations with teachers and from impressions gained from graduate students in university classes.

As a background to observed changes in class procedures in general science it is well to review a few of the things which have been happening to schools. These changes are affecting very materially current practice, although they may be classified as administrative rather than instructional matters.

There is a widespread movement toward single period science schedules. This is especially true of those schools definitely organized as junior high schools. Some four-year high schools and some senior high schools are also going on the single-period schedule. In Kansas City most science classes in both junior and senior high schools are run on this schedule. General science as a junior high school subject is going rapidly over to the single-period basis. The length of the period varies from the regulation 40 or 45 minutes to 50, 55, and 60 minutes. This means considerable reduction in laboratory for those schools attempting to operate on 40 minutes daily. More modern or more radical schools have the longer periods. These schools are able to attempt more laboratory work.

General science classes are getting large. Classes of 30 to 40 are not uncommon. In city schools they may be the rule rather than the exception. Even in village schools where general science is required of ninth graders, sections are large. The old rule of 18, 20, or 24 for science classes has gone by the board. Teaching methods for general science must be adapted to large classes in 1928 and 1929.

There is a tendency to introduce general science into all grades of the junior high school. The course is not always general science. Sometimes it is elementary science, sometimes general science and now and then just science. The intermediate schools of St. Louis have had an elementary science course in all grades of the junior high school for several years. Scattered schools offer the usual general science course in the eighth grade. At least one book company is publishing a general science series with graduated texts for all three years.

There is some tendency to push general science down into the grades. There are courses and texts with general science content for fifth and sixth grades. Some junior high schools offer general science in grades seven and eight and biology in the ninth grade. This is not new. The Bureau of Education bulletin on the "Reorganization of Science for Secondary Schools," published in 1920, recommended this.

A rather large number of schools put general science on a two- or three-hour-a-week schedule. Industrial arts for boys and home economics for girls are often the alternating courses. In some Oklahoma junior high schools these are called finding courses.

The North Central Association and some state departments and University accrediting agencies have put college entrance upon the basis of the twelve units of credit earned in senior high school. This automatically removes general science from the list of college entrance credit courses. The immediate effect is to leave the way open for making the course in general science, and the teaching procedures, most effective for reaching desirable aims in terms of life rather than in terms of accrediting agencies.

The effects of these administrative trends may be summed up as follows: General science is spreading through the grades of the junior high school. There is a tendency to merge elementary science and general science. Schedules and present accrediting tend to free the course from hard and fast regulations and make possible very flexible adaptations to the group of pupils in any particular class. Large classes and single-period schedules tend to limit the amount of individual laboratory work attempted. These same conditions may mean a slipping back into lesson-hearing and memoriter text-recitation devices.

Turning from administrative conditions which may affect teaching procedures to trends in the teaching procedures themselves, the following seem to be the more important tendencies in present-day general science teaching:

1. A reduction in individual laboratory work and a corresponding increase in demonstration and various devices for visual instruction.
2. An increase in the use of moving pictures, slides and still films.
3. An increased flexibility in the type of laboratory work and a corresponding flexibility in the schedule for laboratory work.

4. A reduction in formal note-book work and "writing-up" of experiments, tending toward a complete elimination of the older types of science note-books. This is accompanied by a tendency to use work sheets which cover all types of work to be done.
5. The use of individual and committe reports and pupil demonstrations as a means of providing for individual differences and as a means of fixing pupil responsibility for work done.
6. The formation of science clubs as a part of the function of science departments of high schools.
7. The inclusion of groups of science projects as a part of the regular instructional program of the science class. Point schemes for accrediting and recording credit for such work are in common use.
8. Unit organization, instead of daily lesson organization, is becoming universal in better schools. Several text-books have recognized this principle and are organized on the unit basis. The unit may be a large topic, a problem, a group of problems, or the application and interpretation of an important principle of science.
9. Programs of discursive reading, done for the values which may be derived from the reading rather than as supplementary to the day's lesson, are becoming integral parts of all well conducted general science courses.
10. Work sheets, direction sheets, unit outlines, and instruction sheets which are mimeographed and put into the hands of pupils at the beginning of lesson units, are increasing in use.
11. Objective tests to be applied to the results of instruction for particular lesson units are developing rapidly. In many cases these tests are applied both as initial and as end tests. In some situations unit tests are applied as preliminary tests and as mastery tests after re-teaching.

Certain theoretical advantages seem inherent in these tendencies. Whether they are actually attained in every case of actual use may remain a question. The procedures described would seem to aid in the fixation of responsibility for the work and consequent learning upon the individual pupils. Individual and committee work and reports, and pupil demonstrations serve this function. Science clubs, projects, reading programs, the use of unit organization and the use of work sheets would all seem to serve the same purpose. Unit tests, especially if administered as initial and final tests, may also help.

The group of modern procedures should have the general effect of varying the work of the general science class, furnishing the further possibility of added interest and tending to sustain such interest. Clever and imaginative demonstrations, increased use of pictures and projection equipment, flexibility in problems attacked in the laboratory, reduction in note-book writing, the science club, discursive reading in magazines and semi-popular books, project work, and varied direction sheets should all help in attaining this advantage.

The advantage to be found in several of these newer types of instruction would seem to lie in what we have come to recognize as by-product or concomitant learning. That is, the values derived from some of these schemes would seem to rest in increased interest in scientific phenomena and applications, change in attitude toward scientific experimentation, increased ability to solve one's own problems, and an increased reading power in the field of scientific literature rather than in increased direct control of scientific facts and principles. This would seem to be true for committee reports, pupil demonstration, science clubs, science projects and discursive reading, although there is available evidence to show that the direct results of all of these are positive.

All changes and evolutions carry with them, not only possible advantages, but also possible dangers and difficulties. The color of the male cardinal may be an advantage in his spring courting, but it also has its disadvantage in the face of a mischievous youngster with a twenty-two rifle, or in attempting to escape a prowling cat. So, our trends in science teaching present problems and difficulties.

The details of planning and pupil-accounting sometimes become enormous with certain of the newer schemes. Any teacher who has attempted to develop his own unit outlines, work sheets and unit tests is in a position to speak with feeling upon this point. Proper use, selection and evaluation of picture, film and slide material presents the same difficulty on a smaller scale. Mere flexibility of laboratory work means more careful planning. Checking, recording credit, holding pupil conferences, finding material and doing other planning for committee reports, pupil demonstrations, science clubs, reading programs, and projects may be ever so worth-while but are nevertheless enormously consuming of time and energy.

Certain of our modern tendencies present the danger of slipping into the easiest way out. Single periods, reduced laboratory, increased demonstration, wider use of book materials and printed directions might eventually mean the slipping over into a memoriter scheme of lecturing, note-taking, limited reading, recitation and quizzing. When this happens the time will be ripe for another instructional revolution.

There is some evidence that modern work sheets and lesson

outlines may contain a fairly large amount of mere busy work like the old seat work of the primary schools. Directions which merely keep pupils seemingly busy and quiet may not be educationally worth while. The thing which apparently killed supervised study, as such, may be the ruin of lesson outlines and work sheets.

The advantages of objective tests applied to particular units seem obvious, whether the test be of the commercial type or home-made. We must not ignore the danger, however, that these tests may simply emphasize the memorization of trite and meaningless facts without proper evaluation of worth. There are increasing signs that this danger is near and immediate.

These tendencies, together with their dangers and difficulties, set the stage for some very definite needs in the fields of science teaching. Cycles of fads sweeping the country and then dwindling to a residue of practical and useful material should eventually convince teachers that there is no universal panacea in educational methods. The use of problem organization did not cure all the ills of science teaching. Neither did the introduction of laboratory instruction, nor will the elimination of laboratory instruction and the substitution of lecture demonstration. Project teaching has not solved all the problems of science instruction. It is not probable that mimeographed lesson outlines and directions will offer the one and only cure-all. Let us cease the search for blanket methods of instruction.

If we are going to have courses in general science it is high time that we set forth a body of common sense outcomes that may be expected of our pupils. It is exceedingly difficult to construct unit tests in general science because no one seems to be able to predict what the units should be nor what the outcomes of a particular unit should be. The same situation is true of procedures. Should a particular procedure be used because its description looks well on paper and it seems to have certain theoretical advantages or because other teachers seem to have used the method with success? No. A procedure is to be used when a teacher has first determined upon a group of outcomes for his own class and then decides that a type of procedure gives evidence of being useful in producing such outcomes.

Added to such a common sense point of view concerning current methods we need increased activity in attempts to devise methods which might reasonably aid in producing rather small and specific outcomes. Once such devices are imaginatively produced they need to be clearly and definitely described. The whole field of educational method has been muddled and confused for generations because of the non-existence of any such descriptions. The whole project notion almost died for this reason. Who knows what socialized recitation means, everyone or no one? Science teachers are enormously confused at this minute because the experimenters with educational methods have failed to describe what the methods called individual laboratory instruction and lecture demonstration mean in particular experiments.

With this need for adequate description of useful procedures we need increased inventiveness in the attempt to produce unit tests which may measure other outcomes than mere verbal reproduction of facts and principles. The ultimate evaluation of different types of laboratory instruction awaits the production of such tests.

Finally, we need experimenters in the field of educational procedures with the patience to do real scientific experimentation. The essence of proof in cases where there are many variable factors is often much repetition over long periods of time. We have seldom applied this to educational experiments. Some procedures need to be reapplied and remeasured many times with many pupils and teachers and over periods of years rather than weeks. No agriculturalist would have faith in a crop rotation experiment applied in one season. No wonder that science teachers are skeptical of the results of experiments carried through two or three weeks or a few months. May we have a generation of scientific science teachers who will describe procedures for getting at definite outcomes and will then apply such procedures and measure them over a period of years until some assurance of value or lack of value may be reached.

Home Made Apparatus

O. E. Underhill

Mary C. Wheeler School, Providence, R. I.

If a pupil makes a piece of apparatus and it works, he is apt to understand the principles involved. Also in schools where funds for General Science are limited it may greatly augment the teacher's equipment.

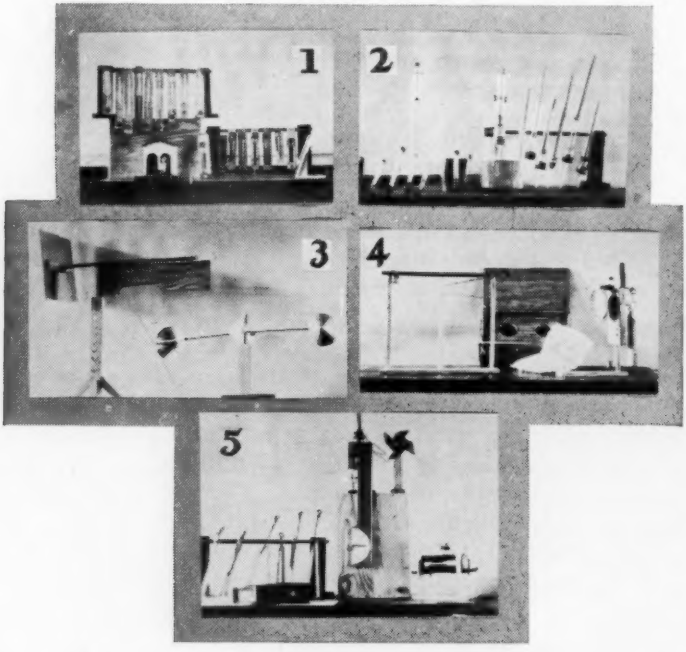
I would state two things as being fundamental for work of this kind. The first is a set of tools and work bench in the General Science room. The school shop may be a great aid but it is a much greater help to have the outfit at hand. The second is a junk box. If the teacher will provide the box any normal class will usually provide the junk.

The purpose of this article is to describe some of this type of home-made apparatus that has been made by some of my students at different times. The greater part of the apparatus described was made last summer in a class of science teachers at the Summer School at Hampton Institute, Virginia. This is a school for negro teachers. Negro schools usually have little money for equipment and the ability to devise apparatus is of great value to these teachers of general science. The course consisted of a three-hour period each day, one hour of which was given to class discussion of methods of teaching, organization of subject matter and so forth, the other two hours being given to actual construction of apparatus.[1] Some of the apparatus described was made by seventh and eighth grade pupils in the Lincoln School of Teachers College, where a work bench and tools is part of the equipment of the general science room, and a few pieces were made by pupils in other schools working at home.

1. Thermometers. Each member of the Hampton class was required to do a unit of work in glass blowing which included the making of a magnifying glass, a medicine drop-

1 A course of this type had been gradually evolving under the direction of Mr. W. G. Whitman, who conducted classes in Science, at Hampton, for several summers, and with the co-operation and advice of Dr. George P. Phenix, Director of the Summer School. But this was the first summer when the construction of apparatus, for the teachers to take back to their own schools, was made a major purpose of the course.

per, a medicine tube, various bends for setting up apparatus, and a thermometer. The thermometer was made by blowing a small bulb in a piece of small bore tubing, allowing some colored alcohol to be drawn into the tube as it cooled, setting the tube in water at a sufficient temperature to expand the alcohol, and sealing the tube while in the water. It was then put in boiling water, and in ice to determine the fixed



points, and mounted on a board with a graduated scale attached. One may correlate with geometry at this point if desired by using the geometrical method of dividing a line into an equal number of parts, as the distance on the scale between the freezing and boiling points must be divided into equal parts. Figure 1 shows some of these thermometers.

2. HYDROMETERS. These were made by putting shot into a test tube until it balanced upright, inserting a paper scale,

and testing it in salt solution of known density to construct the scale. One or two of the more ambitious students tried blowing bulbs in test tubes and attaching them to a glass tubing scale to more nearly approximate the form of the commercial type. A group of the test tube hydrometers is shown at the left of Figure 2. Some care is required in choosing a test tube of proper proportions so that it will balance in an upright position.

3. CHEMICAL BAROMETERS AND HYGROMETERS. A chemical barometer may be made by mixing the following chemicals: 2 oz. water, 2 oz. abs. alcohol, ½ dram ammonium chloride, ½ dram potassium nitrate, 2 drams camphor. The mixture is sealed in a test tube and mounted on a black background. White crystals are formed which settle to the bottom in fair weather, and separate out throughout the liquid prior to a storm. If the proportions are not gotten exact and no crystals form a few drops of water may be carefully added until the crystals form. If the precipitate is too heavy a few drops of alcohol will dissolve some of it. If 95% alcohol is available instead of absolute, slightly less water should be used. Figure 1 shows a group of these barometers.

There are various forms of hygrometers which can be made that indicate the humidity by a change in color. Several formulas are given in Hodgdon's General Science, page 16.

A charming weather cottage was made by one of the girls in my Hampton class. It is shown in Figure 1. The dolls were a pair of French china dolls that the student happened to have. These were mounted on a turn table, balanced with shot, and hung from a gut string (a violin string). This cottage was extremely sensitive and would shift during our morning class, indicating the coming storms quite accurately.

5. ANEMOMETER. See Figure 3 right. The funnels are cut from galvanized iron. One made by one of my Lincoln School pupils used funnels bought at the ten cent store, with the tips cut off and the holes plugged with corks. It was the intention of this boy to gear the revolving vanes by means of alarm clock gears to a sliding contact so that a flashlight bulb would light every so many revolutions, thus enabling one to count the revolutions per minute and make comparative observations, but time was not available for carrying this out.

6. WIND PRESSURE GAUGE. Figure 3 left. The board is just one foot square. The scale is made by pulling against the spring with a balance, marking the scale to read in pounds. Thus the gauge reads directly in pounds per square foot. The spring was wound of spring brass wire.

7. PUMP MODELS. These are made from Argand lamp chimneys, dowel handles, stoppers and rubber or leather for valves. Some of these are shown in Figure 2, right. Pump model making offers much opportunity for originality.

8. FIRELESS COOKER. Center Figure 4. One fireless cooker of this type was made by a boy in a Massachusetts junior high school in the city where I was teaching in the senior high school, that was purchased by the domestic science department of the senior high school for a demonstration model. The boy's father worked in sheet aluminum and the boy was able to make a wooden box lined with aluminum. The model was worked out accurately to the last detail. This is described in a fireless cooker project written up in the General Science Quarterly 10:4:568, May, 1926.

9. TIME-KEEPING DEVICES. Two types of time-keeping devices are shown in Figure 4. At the left is a device in which an elastic furnishes the motive power and a weight at the end of a string regulates the speed of revolution. At the right is a model of a clock escapement. I have among my apparatus an alarm clock which has been taken part and a pendulum soldered to the escapement so that it may be used to illustrate the regulating effect of the pendulum and escapement on the speed of the clock. Other pupils have made water clock models of various kinds, the most common form being made of two tin cans so arranged that as water drips from one into the other a float is caused to rise.

10. HEAT EXPANSION APPARATUS. At the left of Figure 5 is shown several sets of ball and ring apparatus made from two screw eyes mounted in handles. The smaller screw eye will not pass through the larger one when it is cold but will slip through when the large one has been heated.

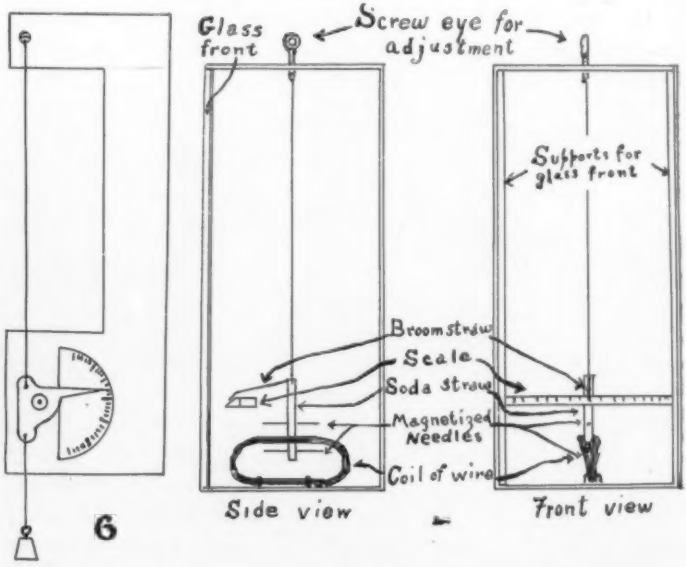
A special form of apparatus to show the expansion of a wire is shown in the center of Figure 5. A diagram showing the construction is shown in Figure 6. The heat from a match held against the wire will cause it to operate.

11. WORK OF WIND. To show that wind will do work. Center Figure 5.

12. TIN CAN STEAM ENGINE. Right Figure 5.

13. GALVANOMETERS. Two galvanometers of the general type shown in Figure 7 although varying somewhat in detail were made at Hampton.

14. TIN CAN DRY CELLS. A tin baking powder can was lined with cardboard and a paste of 1/3 powdered graphite,



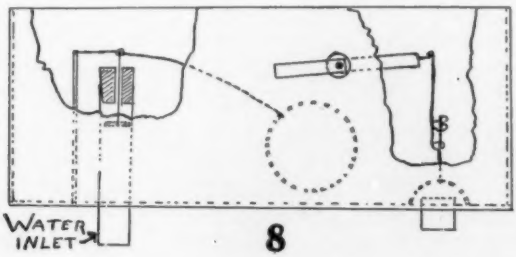
1/3 sal ammoniac and 1/3 manganese dioxide added. A carbon from an old dry cell was placed in the center, sand sprinkled over the mixture, and the whole sealed with wax from the tops of old dry cells. The wire clip from an old dry cell was soldered onto the tin can. Such a cell will light a flashlight battery. (?)

16. FLUSH TANK MODEL. See Figure 8. A rubber ball was used for the float and half a smaller rubber ball for the outlet valve.

17. SWITCHBOARDS. Various kinds of switches, fuse blocks, flashlight bulbs, bells, etc., were wired onto the bottom of a wooden box. Batteries, etc., were concealed within the box. This gives practice in making connections and in working out circuits.

18. ELECTRIC MOTORS. Several electric motors were made following the plan in Caldwell, Eikenberry and Glenn's Laboratory Manual. Old Ford generator magnets were used for the field magnets. It is surprising how well such a simple motor will run.

19. OERSTED'S LAW APPARATUS, ventilation boxes, etc., need no special description. A pin-hole camera is shown in the foreground at left of Figure 5.



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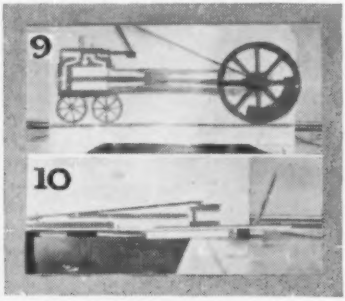
20. ELECTROLYSIS APPARATUS. Two carbons from a flashlight cell were thrust through the holes of a two-hole rubber stopper, heavy insulated copper wire leads soldered to the brass caps, and the joints insulated with friction tape. This is immersed in a battery jar of acidulated water and test tubes inverted over the carbons to catch the gases liberated.

21. MACHINE MODELS.

One piece of work by two girls in my class at the Lincoln School has suggested ideas that I think could profitably be carried further in the making of models. A model steam engine was made from light wood, having movable parts. The model was about four feet or more long. The engine frame was painted in black as a background and the movable parts such as piston, valves, eccentric, flywheel, valve rods and piston

rods were made of thin wood. The result was a large model that could be easily seen by the whole class, and that could be manipulated to show the action of the valves and piston. Also the two girls, after they had figured out how to get the eccentric, flywheel and crankshaft rod onto the one shaft without interference, knew what the bend in a crankshaft was for. See Figures 9 and 10.



I have in my files over two hundred suggestions for construction of apparatus. I hope to be able to work out more of this next summer and perhaps to formulate a bibliography which will aid science teachers in locating suggestions for this type of work.

Dayton C. Miller Maintains Ether-Drift Belief

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DR. Dayton C. Miller, back in his office at Case School of Applied Science after attending the meetings of the Optical Society of America in Washington, still contends that there is a positive result from his ten years or more of constant observation which points conclusively to the fact that there is an ether drift.

Professor Albert A. Michelson addressed the Optical Society of America upon his experiments which he in collaboration

with the late Professor Morley, performed in 1887; he was then Professor of Physics at Case. He has repeated these experiments and has concluded that there is no drift of the ether, since all his results are zero.

Dr. Miller devoted himself to constant study of this phenomena in 1902-1906 when he repeated the Michelson-Morley experiments and found a small positive effect. From 1921 to 1927 he made more elaborate observations on Mt. Union and in every case he found a small positive effect, a direct contradiction to one of the fundamental postulates of the Einstein Relativity Theory.

When called upon to state his position during the recent New York meeting, Dr. Miller said, "When I began my experiments I had the honest expectation of arriving at a negative result also. But the experiments have always yielded a positive result. For this reason I feel compelled to continue the investigation."

Dr. Miller believes the conditions under which Professor Michelson has worked may be different, perhaps the procedure varies and thus renders the results incomparable-Michelson did not explain. On one thing he is certain—that there is an ether. Michelson supposedly concurs in this. Einstein does not commit himself, for the ether is entirely ignored in his relativity theory.

Fired with a new zeal to prove his theory, Dr. Miller said, that he expects immediately to continue observations in Cleveland. During the past summer Dr. Miller and his assistants resilvered all optical parts and enlarged the Interferometer Laboratory to do away with temperature disturbances caused by the proximity of the walls to the delicate instruments. Some shock absorbing material will be placed to reduce the traffic vibrations which have hindered him in his study.

With renewed purpose Dr. Miller hopes to bring conclusive positive proof of the drift of ether—the unfelt, unseen, mythical something which surrounds us and through which light and radio waves travel.

Supplementary Aids in Teaching General Science

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Textbooks supply the teacher and pupil with the basal subject matter, or they may serve as an outline course They are necessary and I am not urging any other materials to take their place; but they are, more or less, static. Even with constant revisions it is impossible to keep them up to date with the latest developments in science. This is one reason for urging supplementary materials which will help relate science to the experiences of the pupils.

Further, the teaching of general science has been introduced into our schools so rapidly that teachers are often confronted with the problem of securing adequate materials Until proper rooms and minimum supplies are provided by the boards of education, teachers may secure a wealth of materials without cost by simply requesting them from various sources.

Even though schools are equipped with the regular modern apparatus and supplies the progressive teacher is seeking the best available periodicals, reference books, government bulletins, materials from commercial firms, pictures, exhibits, lantern slides, and films. The tendency is and will be for some of these special teaching aids to become regular standard equipment and materials.

The ever-increasing demand for materials in connection with units of instruction in several of the subjects in our schools has led to this attempt to find, test, and classify the visual and other materials as special teaching aids from commercial concerns.

The evidence of a real need for such materials came in the form of requests from teachers not only in Cleveland but from schools in many other cities. Further and more urgent demands for teaching aids were realized in preparing the tentative courses in Elementary Science and in making lists of materials for other science subjects. Again, demands were made on the writer by the students in his course, "The Teaching of Elementary Science," offered in the School of Education, for actual materials for certain units.

A list of firms was obtained from the advertisements in ten of the popular magazines. Letters were sent to these firms to determine what materials were available to the schools and what was the nature of such materials. Reference to lists already available such as Roller, D. E., University of Oklahoma Bulletin, *Sources of Free Materials for Use in the Teaching of Natural Science;* Frank, J. O., *How to Teach General Science,* pages 196-223; Griffith, Fay and Lott, Mamie O., *Illustrative Materials Useful in Elementary Grades and Junior High School;* was made for other sources. Letters were sent to these companies to learn if these materials were still available and to find if new aids had been added to their lists.

The replies were sorted into the following groups: Those that did not have materials or did not wish the name to appear in our list; those that had free materials; and those that made a small charge for their exhibits.

The materials are being examined and checked to the following criteria which were set up for this purpose:

(a) MATERIALS

Materials must help illustrate a certain lesson or field of subject matter.

(b) SUBJECT MATTER

Subject matter must be accurate of statement. Signed articles or bulletins giving the author's name were given preference. For example: The splendid pamphlet entitled "The Magic of Communication," by John Mills, is a most fascinating and accurate science story.

(c) READING MATERIALS

Reading materials must not contain propaganda.

In some cases these materials were tried out in the classroom before listing. Only those which have been judged most helpful to teachers and pupils have been included. When materials were discovered that could be used in connection with certain units, permission to include them in our list was obtained. It was often necessary to send them two or more letters before definite statements granting the right to suggest their materials was given. This means that the companies whose names appear are willing to comply with the teacher's requests so long as their supplies last.

New materials are constantly appearing and it may not always be possible to obtain the items listed since firms change their advertising materials frequently, but others equally valu-

able may usually be obtained from the sources listed here. If the supply of items requested has been exhausted, the firms will often make substitutions as a special favor to the teacher. Therefore it is advisable to make requests for specific materials stating the unit for which they are to be used so that new items can be sent to meet these needs.

Unless materials of this kind are classified in some way so that they are easily available, teachers are not likely to use them. Therefore, it is important to decide upon a system for filing and storing them as they are received. For this reason the system which I have worked out for our department is given somewhat in detail. It is a simple but effective plan. As the booklets, pamphlets, charts and exhibits came in they were examined and placed under the subjects to which they pertain and the specific sub-topics under those subjects. Each article was also appraised as to its suitability for the different branches of science, such as elementary science, general science, biology, physics, and chemistry.

In order to locate our materials quickly we had to have a system of filing cards. Consequently, as the materials were received and classified the information was typed on to filing cards 5x3 inches. The cards contain the main subject and specific sub-topics, the names of the booklets or exhibits, the branch of science they were most adapted for, and the name and address of the firm sending such material. The complete filing card looks like the following:

COMMUNICATION.
Telephones and Telegraphs.
1. Magic of Communication. (pamphlet)
2. Things worth knowing about the Telephone
3. The 1927 Telephone almanac.
4. The Birth and Babyhood of the Telephone.
5. Through Electrical Eyes.
(Elementary and General Science.)
American Telephone and Telegraph Co.,
195 Broadway, New York City.

The material consists of booklets, pamphlets, charts, maps, and exhibits. These have been classified alphabetically under the following headings: Animals; Apparatus; Building; Clothing; Communication; Electricity; Food; Health; Industrial Processes; Inventions; Light; Mechanical Devices;

Plants; Rocks; Minerals and Metals; Safety Education; Time Telling; Transportation and Travel; Weather; and Miscellaneous. Each of these headings, of course, is divided into several sub-headings.

All of the classifications are simple and familiar; therefore it is very easy to locate material. If a teacher wishes material on the subject of telephone for instance she simply turns to the heading *Communication* and the sub-heading Telephones.

Some overlapping of material, of course, is bound to occur. Consequently, when material may be found under two headings cross-references are used. For instance, material on milk may be found under *Food*, Milk, and also under *Health*, Milk. This system makes possible the quick and effective location of all available material on a subject.

After the materials were listed on the filing cards they were placed in the cabinet and arranged under the main headings of the cards. Large 12x8 inch boxes, three inches deep were used to store the pamphlets. The exhibits were placed in order in a show case. The maps were tabulated with the main card heading and arranged in a drawer.

By this method knowledge and location of certain materials may be quickly obtained by glancing through the card files; securing of such materials may be had by referring to the corresponding sections of the cabinet. Although items from the above sources are useful teaching aids they by no means include all the helpful supplementary materials. Time will not permit me to treat in detail all the other sources but I might mention those which will bring this subject in a general way up to date.

The importance of supplementary reading has been indicated by a study made by Curtis.[1] Among the magazines which have been found useful to supplement the regular textbook are the following: *Popular Science Monthly, Popular Mechanics Magazine, Science and Invention. Scientific American, American Forests and Forest Life, Nature Magazine, Current Science,* and others.

Teachers with funds available for enlarging the library of popular books on science should consult the High School Sci-

1 Francis D. Curtis—Some Values Derived from Extensive Readings in General Science." Contribution to Education, No. 163, New York, Teachers College.

ence Library by H. A. Webb, published each year since 1924. Two sets of books dealing exclusively with science and which have been found helpful in the science work are Outlines of Science (4 volumes) and The Book of Popular Science (15 volumes). Both of these sets deserve special mention for reading in Junior and Senior High school science.

A large number of government bulletins are available for references and may be had for the asking. *The Beaver Habits and Experiments in Beaver Culture,* by Vernon Bailey, Technical Bulletin No. 21 is a good example of the splendid reference material which may be obtained free. Teachers should request the Department of Agriculture to send the list of new publications each month. Then it requires very little time to check the items desired and return the list. Gradually build up a library of bulletins which can be used in connection with certain units of your course.

(d) PICTURES

In Cleveland pictures are now available through the Educational Museum under the direction of W. M. Gregory. These pictures are made up into sets for a specific unit of instruction. For example, if the unit should be domesticated animals, the teacher may order from the Educational Museum the set of pictures prepared for this unit in the course of study. In other large cities visual materials are distributed to the schools in a similar way. Excellent pictures of animals may be had from the Bureau of Animal Industry, Washington, D. C. Still other splendid pictures for certain units may be obtained from the Grolier Society, New York.

(e) EXHIBITS AND MODELS

The more costly exhibits and models are also available to our schools from the Educational Museum. We are not warranted in asking schools to make large expenditures for materials which are used for a few minutes and then placed in our store room until next year. From the museum the same exhibit may serve ten to fifteen schools during a semester. For example: the phametarium, models of eye, ear, reproduction of the frog, and others, are distributed from our Educational Museum.

(f) LANTERN SLIDES

Lantern slides are available from certain commercial firms, from the United States Government, and from the supply houses. Certain firms, as you know, are arranging their slides into sets with specific directions for their use. In Cleveland the slides have been purchased from various sources and arranged into sets to meet the needs of definitely organized units in the courses of study. For example, in the primary grades, The Robin, is the title for one set. These slides tell the life story of a robin. They show the male, the female, the nest, the eggs, the young, the feeding and care of the young. With each set are essential facts about the topic for the teacher's use. Lantern slides are becoming a regular teaching device in many schools.

(g) FILMS

Another type of visual aid which should claim our attention is the motion picture. These films offer wonderful opportunities for the learning of science, as has been shown by the experiments conducted by Dr. Ben D. Wood and Dr. Frank N. Freeman for the Eastman Kodak Company. The 5,500 children taught with the aid of motion pictures showed a gain of 33 per cent in geography, and a 15 per cent gain in general science over the score of 5,500 children taught without the aid of films.

Even with this evidence in favor of the use of films there are still several problems confronting us before they can be extensively used as a teaching device.

First, we need films made for specific units in our courses of study in the elementary, junior high, and senior high schools. There have been available for several years a more or less limited library of films from several sources, but these have been general in nature and by no means meet the present needs. As you know, there is a growing tendency to develop special school films for science and other subjects.

Secondly, we have the problem of cost, which is an item we must consider. If schools cannot afford to buy a complete library they should be able to supplement their library or depend entirely upon a central main library. In Cleveland the films are purchased and placed in the Educational Museum. They are then distributed to the schools for a loan period as needed.

How long we may class some of these materials as supplementary instead of standard teaching aids remains to be seen, but whatever their classification they must be considered essential teaching helps.

It seems to me that our problem is to find the available materials, and classify them for use in connection with specific units. Then make the best use of them to vitalize our science courses and to relate the world about us to the experiences of the pupils.

Collecting As An Educational Factor

C. W. Garman

State Teachers College, East Stroudsburg, Pa.

What teacher has not spent many a restless night wondering how he or she could manage that energetic pupil who finds so much time for doing things which he is not supposed to do, which contribute nothing to the subject in hand, and serve only to complicate the age-old problem of discipline?

All teachers have faced this situation at some time or other and have solved the problem in this or that way, but not always in the easiest or most profitable way.

The writer, who has been teaching for several years, wishes to suggest a means of motivating pupils and vitalizing the subject matter so as to utilize all surplus energy, thus solving the problem of discipline and adding momentum, enthusiasm and interest to the work in hand.

Students are in many respects like adults, in that they love to have avocations wherein they can give expression to what lies within them, to work out their natural propensities, to do some constructive work which gives expression to their individuality, and to feel that they can achieve something which is praiseworthy without having someone continually at their elbow giving directions.

The secret lies in the teacher starting something which makes an appeal to the natural instincts and propensities of pupils on their respective grade levels and according to their individual differences.

The value lies not only in motivation and inspiration for the work in hand during the school life of the students, but in the matter of habit formation which is of such vital importance to the individual in adult life.

It is a natural instinct for people of all ages to collect something or other and to store it somewhere and to contemplate upon it at different times and to try to determine its relative value or importance and its relation to the numerous things which he observes upon every hand. Here the element of curiosity is beginning to function and, as Aristotle tells us, "curiosity is the beginning of knowledge."

Very young children will gather pebbles, shells, flowers, and all sorts of brightly colored and curious looking objects and store them in some definite place and return to handle and contemplate upon them. They refer to them as "mine," and are greatly perturbed when thoughtless people disturb their treasure "cache." Here individuality and ownership and pride are beginning to develop in the child.

Now, for the sake of brevity, let us consider a few random projects which have been found to work out well in the writer's experience.

The field of Nature Study offers us a great opportunity, because it is so broad and so full of inspirational material that no matter where or when we turn to this source for our subject matter we find it meeting us more than half way, and furthermore the pupils when once started upon a project need very little guidance.

Let us first make a list of a few topics which are most commonly chosen from this field. They are: Bird pictures, butterflies, butterfly pictures, moths, moth pictures, insects, insect pictures, cocoons, brids' nests, birds' eggs, feathers, small turtles, turtle eggs, frog eggs, toad eggs, salamander eggs, flowers, weeds, grasses, leaves, roots, tubers, fruits, specimens of various sorts of lumber, different kinds of bark, fabrics, rocks, metals, traps of all sorts, pictures of various types of fish, snakes, salamanders, burrowing animals, nocturnal animals, hiberating animals, fur-bearing animals, carnivorous animals, herbiverous animals, etc. Metamorphosis in its various stages as shown by the butterfly, dragonfly, frog, toad, salamander, These few suggestions may serve to illustrate the nature of the topics which have been found to be of common interest.

Now as to the equipment for preserving and mounting, the following materials have been found to be very convenient: A 4% solution of formaldehyde, a can of LePage liquid glue, a quantity of pins, some gasoline or ether for killing, some boards of any convenient size, a quantity of small glass bottles, a pair of scissors, a gimlet, a pocket knife, some fine copper wire, etc.

Those students who are interested in collecting pictures, usually find it convenient to mount them upon rather heavy cardboard which has been cut into convenient but uniform sizes.

A convenient filing-box can be devised by most any boy after receiving a few suggestions from the teacher.

Those students desiring to mount a collection of rocks will find it desirable to mount them upon a board about four feet long, one foot wide and about a quarter-inch thick. The rocks are wired to the board in some orderly fashion and enough space is left between specimens to allow room for a card bearing the name and classification of each specimen. The boards should be painted white.

Those interested in collecting insects should secure a quantity of small vials from a drug store and mount them in rows upon a board like that mentioned above. The bottles should be nearly filled with a 4% solution of formaldehyde, the corks inserted, and then the student is ready to begin his hunt for the desired specimens.

For capturing and killing the insects the student may use any large-mouthed bottle containing a small quantity of ether or gasoline, and he should keep the bottle corked or in a few minutes he will be wondering what became of the ether.

As soon as a specimen is mounted it should be named and classified on the card which is placed just beneath this bottle.

Those who collect butterflies, moths and cocoons, etc., can glue them directly upon the board. It is preferable to lay these insects with their backs against the boards, so that their wings do not become broken.

The eggs of the turtles, frogs, toads, salamanders, etc., are preserved in formaldehyde and mounted in bottles upon the boards.

The birds' eggs should be emptied of their contents by making a small hole in each end of the shell and then blowing out the contents.

After collections have been made or while they are being made, the teacher should provide a place in the room where the collections can be observed and studied by other pupils whenever occasion permits. It is indeed gratifying to observe with what absorbing interest the students will watch the growth of the various collections.

The projects need not be carried out entirely by individuals, for it is often found to be advisable to have students work in groups, and thus they develop a cooperative spirit.

There are various occasions when a few minutes can be very well spent by having the whole class or all the pupils in the room give their attention to a pupil who has prepared a talk upon his favorite project. It may pertain to the life-history of some animal, or its feeding habits or nesting habits, or its economic importance, etc.

Patrons who have never been induced to visit the school before, have come very willingly to see their boy's collection and to hear him tell about it.

For collecting live specimens from the pond or stream it is advisable to have several small aquariums instead of one large one, in order to separate those insects and animals which may devour or injure each other. Then, too, the small aquariums can be handled more easily when the materials are being used as the subject of a lesson or talk. They are also more easily kept clean, and they can be stored more conveniently in differant parts of the room. Also the element of individual ownership and responsibility is brought into play, and this is a great aid to the success of the whole proposition.

In closing, we may say that the art of skillful teaching involves the setting forth of a definite and worthy aim or objective which appeals to the natural propensities, interest and abilities of the pupils on their respective grade levels and according to their individuality. The teacher has ceased to be the master and becomes a partner with a controlling interest in the activities of the school.

Camping: Ninth Grade Science

THOMAS MCCLUNPHA
Theodore Roosevelt Junior High School
Amsterdam, New York

The Camp Environment

1. How can we identify the trees about the camp?
2. What kinds of rock and soil are found?
3. How was sedimentary rock formed?
4. What uses do we make of clay?
5. Of what value are the birds in our environment?

6. How can we identify the various reptiles and amphibians in our environment (snakes, turtles, frogs, salamanders, etc).
7. What plants, insects, and snakes are poisonous?
8. In what ways can we make the camp more attractive?
9. Make a plan of the camp shack.

Activities at Camp

1. How can we measure the height of a tree?
2. What games can we best play at camp?
3. How can we estimate approximate time?
4. What use shall we make of our camera?
5. How does a camera take pictures?
6. What causes an echo?
7. What books would be valuable on a camping trip?
8. How can we identify the more prominent stars in the sky at night?

Fire

1. How can we start a fire without matches?
2. What is smoke? Why does a fire smoke?
3. What happens to things when they burn?
4. Which woods make the best fuel?
5. What precautions can we take to guard against fire?

Food and Water

1. How can we test the water for purity? How can we make it safe?
2. What foods can we get from the woods (nuts, berries, animals, fish)?
3. Where do we seek wild honey? How is it obtained from a tree?
4. How can we make "French toast", pancakes?

First Aid and Health

1. How can we treat artery cuts, wounds, sunburn, frostbite, snake-bite, poison ivy, broken bones?
2. How can we revive a drowned person?
3. What effect does exercise have on circulation (heart beat)?

Construction Activities

Bird houses	Fungus paintings	Whistles
Airplane models	Camera pictures	Popgun from bark
Bow and arrows	Model camp	Baskets
Chairs	Weather instruments	Grates
Canoes	Fireplace	Sun-dial
Tables	Snowshoes	Balsam pillows

Mounting animals

General

How can we tell our way if lost?
How is a boat made stable in the water?
What collections can we make from the woods?
How are living things adapted to their environment?
What use can we make of our jackknife?

DO YOU KNOW

1. That reading in a dim twilight light hurts your eyes?
2. That looking at an intensely bright light, as the sun, has caused blindness?
3. That a bright light in your field of vision is harmful?
4. That using your eyes in a flickering light causes eye strain?
5. That sharp contrasts of light and shade in a room are bad for the eyes?
6. That glare diminishes the visibility of objects?
7. That the treatment of the ceilings and walls are involved in good lighting?
8. That dust on the globes, shades and reflectors impare the efficiency of the lighting?
9. That colored garments often appear different by artificial light which is deficient in blue rays?
10. That portable lamps are a great aid to the efficient lighting of a house?

Grinding—And Its Service to the World[1]

HOWARD W. DUNBAR
Norton Company, Worcester, Mass.

THE grinding wheel still remains in obscurity — in the mind of the layman an insignificant product used to sharpen a knife or brighten a bit of brass, few realizing that the security of our industrial life rests in the ability of the grinding wheel to shape and fashion hard steel parts to a degree of perfection difficult to perceive. And service is the all important quality of the grinding wheel. Service is the key-note to success in any line of endeavor.

I wish I could take you into a big production plant where automobiles are turned out like sausages from the proverbial sausage machine, to see there the huge batteries of grinding machines, yes, actually hundreds of them in one room, and all devoted solely to precision grinding, performing quickly and easily work that could not be done at all before, or could be done only with vastly increased cost for labor.

Let's turn our minds backward a bit and examine into the progress of mechanical art as it comes down through the ages.

Years ago man sharpened his knife by rubbing it upon an abrasive rock dug from the earth. And later the first of husbandmen whetted his sickle in a similar fashion. Tubal Cain must have had a grindstone when he taught primitive man how to make implements from iron and brass. Young Abel may have turned Father Adam's grindstone to sharpen his crude implements when he would have preferred to go fishing or play pirate. Long generations of farmer boys continue young Abel's job, until inventors have furnished a contrivance for revolving a grindstone with the foot.

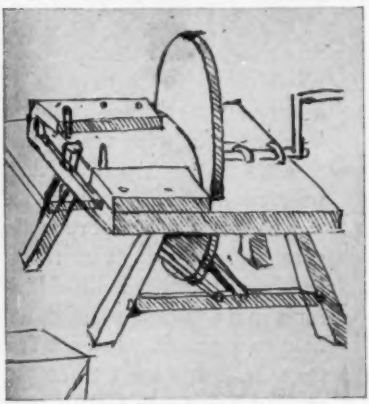
From these crude beginnings came the emery wheel, made from emery, a natural abrasive, and later, necessity led to the discovery of Corundum, another of nature's abrasives. At first wheels were made from these materials by crushing and, when mixed with a binder, such as glue, and allowed to harden

1 Excerpts from a talk presented before Canadian Railway Club. Reprinted from "Grits and Grinds."

in a mould, they became man's first grinding wheels. Later, more refined methods were adopted.

As man's occupations and trades increased, his demands for comforts and conveniences have multipled; so that invention has been necessary to satisfy the crying need for the things to serve civilization. Inventive genius has developed the loom, the sewing machine, the steam engine, the steamboat, the printing press, the automobile, aeroplane, and so on, and as these things have been supplied, means for their fabrication have had to be devised. So the stone that was formerly dug from the earth or hewn from the mountain side has lost its place to a more efficient abrading material made artificially, and from which the modern grinding wheel is now manufactured. Indeed, we might call it synthetic corundum or energy.

Grinder—1834



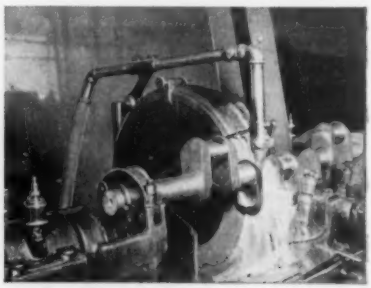
Grindstone—1500

And what of this seemingly unimportant discovery of the research chemist? Where does it come from, and where does it go? To what use is it put, and how will its application in the future lead to greater comforts, more convenience, and further knit itself into the fabric of our industrial life that it may become a still more indispensable implement of fabrication?

The past 50 years have achieved more in adapting natural products to the needs of mankind than have been achieved in all of the centuries before. Thus we have steel and other

alloys, tough and hard, used for fast moving mechanical devices. We have the modern passenger liners bridging the Atlantic in five days, aeroplanes bridging the country in one, automobiles and machinery for almost every conceivable purpose. Yet 99 out of every 100 of us never realize that we could never have created the thousand and one machines that prosper us in every aspect of our daily life had it not been for those who were everlastingly at work to invent machinery, methods and technique. And in this the grinding wheel plays no small part made from a material harder than anything known except the diamond, having for its purpose the mastery of the hardest metals that can be fashioned into shapes suitable to build machines that furnish us with our daily needs.

Heavy-duty Trucks cover thousands of ton-miles yearly.



The "Backbone of the Motor" is produced in its present state of perfection by grinding.

It will be gathered then, that we have a rather little known, but indispensable and important, industrial art, called grinding. In fact, grinding simply has made possible this Metal Age, this Age of Machinery, this Iron Age that we live in. Grinding has made precision in quantity production possible at low costs. Grinding has made the automobile possible. Without the grinding process automobiles would be so expensive that only the richest could afford to use them. Not the humblest machine shop in all our industrial world could operate without grinding, even though it be so small that it uses grinding only for sharpening the tools used in other machining operations.

The grinding practice grows out of the ages of long ago,

away back in those prehistoric times when this world began. In our younger days when the school room was the scene of our activities we were told of a wonderful, but then almost incomprehensible theory called the "nebular hypothesis." This has to do with the manner in which our world came into being. In the exposition of this theory we were taught that on one stage, rock material, of which the crust of the earth is composed, was in a molten condition. The various materials making up this molten mass had chemical likes and dislikes for each other. So there was a good deal of choosing of partners, resulting in the variety of solidified rocks as we find them today, scattered over the surface of the earth. For example, we find down in the State of Arkansas there is a granite-like rock, peculiarly different from most rocks of this character found elsewhere. Technically, this rock is known as syenite. It differs from most granite formations in that it contains no quartz. It has taken millions of years, probably since the formation of the earth, to bring it to its present hardness and density.

Geologically, time is measured by an extremely long yardstick. Changes are taking place day by day in the earth's surface and the countryside surrounding us. It is taking on new characteristics resulting from the decomposition of materials, atmospheric action, action of gases, heat, sunlight, and so on. But these changes are so small as to be imperceptible, except as we measure them by many years. The geologist is rather unceremonious in speaking of millions of years. Now what we call syenite is only an intermediate step towards the formation of bauxite, the material from which artificial abrasives are made.

Many forces have been at work in bringing about these changes, and these natural wizards are none other than those commonly known and united forces of water, wind, frost and the gases ever present in our atmosphere. Water and gases in the atmosphere have been effective in the region around Bauxite, that locality in Arkansas where the base material for artificial abrasives is mined. This rock has a chalk-like appearance, lighter than most rocks as you weigh it in your hand. It varies in color from grayish glassy crystals to dull, shiny black material, and down through the color scale includ-

ing white and pink. This material contains a considerable amount of moisture. This must be removed and therefore, it has to go through a calcining process. The calciner consists of a huge rotary furnace. The material rolls down through an inclined revolving drum heated up to a temperature sufficient to drive out all of the moisture. It is then shipped to Niagara where it is treated by those huge electric furnaces which are supplied with the tremendous energy of Niagara Falls, harnessed for man's use, another accomplishment of the pioneers who have developed those wonders of electro-chemistry and electro-metallurgy that have meant so much to the world's progress.

Niagara Falls, where the electric power is generated for the electric furnaces for producing Alundum and Crystolon abrasives.

Electric Furnace room at Niagara Falls, with huge "pigs" of abrasive in foreground.

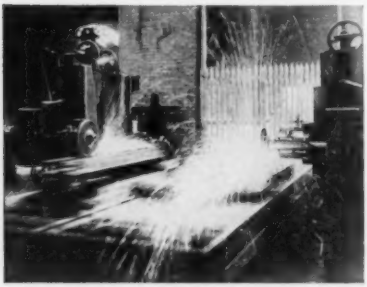
Here at Niagara has been written much of the industrial history of our present day engineering prowess. And one of these achievements is that material which is being made from the bauxite which, when fused under the electric current, is known to the world by the trade-mark "Alundum," used in the form of grinding wheels wherever steel is known, because of its ability to fashion and finish the hardest steel. Only the purest material is used, and a corps of trained technical men watch with untiring diligence for variations in its quality.

It is interesting to watch even the commonplace operations —the truckman as he pushes his pans and scales under the outlets of the various bins, and weighs out with extreme care the right proportions of ore and chemicals, preparing them

for their treatment in later processes. Accuracy is all-important, for the laboratory formulas must be followed to a degree almost inconceivable to the mind.

As we peer through blue glasses into the huge furnace, after the charge has been placed there, we see the bubbling ore and hear the current hissing—no word picture can adequately portray the scene before our eyes. One senses that he is in the presence of a gigantic force controlled by man for the welfare of the human race.

Perhaps it is not so much the ocular evidence as it is the to the imagination. Here a natural substance, bauxite, a soft chalk-like material, is fused under a tremendous heat and transformed into crystals so hard that they can cut the most



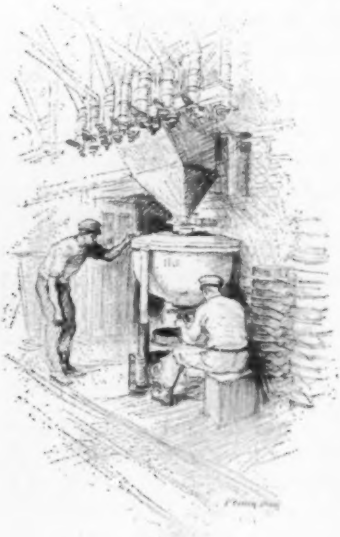
Special grinding equipment in the steel industry.

Speed and Safety—Grinding has its part.

resistant alloys, and are even used to shape the intricate designs in cut glass. Greater interest is developed when one realizes that by the mere addition of certain oxides even rubies and sapphires can be produced from the same material and by the same process. Then indeed it does seem that man is wresting from nature her innermost secrets.

After the required time for fusion, the mass is allowed to cool, then removed from the furnace, crushed by huge crushers, jaws of which break into pieces the size of coal; sorted, selected and shipped to the wheel plant where it is ready for further treatment. Its journey to the point where mechanical processes begin to play a part in the shaping of the wheel is interspersed with many an interruption for further inspection, examination and sorting until indeed the material must feel itself to be the thoroughbred of its class.

In the wheel plant the material takes on quite a different life, for here it must be shaped and fashioned by mechanical operations. Coal-like lumps are again put through crushers and broken up into very fine grains, ranging in size from flour-like material to granules the size of a pea. Grain sizing is a particularly important operation. Much of the character of the wheel action, when later it is called upon to perform its task in some machine plant, depends upon the uniformity,



"Puddling" a Wheel

Kiln Firing

shape and size of the grains used. The sorting is done over large mechanical sieves, and as the grain trickles down into the containers, one must marvel at the cleanliness of each little particle—how the facets shine, reflecting the physical properties for toughness and ability to do their task and do it well!

Another step takes us into the realm of our childhood days, days when we made mud pies in the street after a rain storm, for the next operation is the mixing of the abrasives with a clay bonding material and water. This is poured into pan-shaped receptacles and resembles very closely the mud pies of our childhood. Water is driven off in the dry room, and the

wheel shaped mechanically to approximate dimensions and then fired in a kiln under tremendous heat. A great many days are required to vitrify some of the wheels. The temperature must be watched very carefully, brought up to heat gradually and uniformly, and allowed to cool off in like manner.

Following the kiln operation comes a further machining treatment, that of making the wheel to exact size, supplying the bushings, and putting on the finishing touches. It goes without saying, when we remember the care with which we inspected the raw material, that the same painstaking inspection methods follow through the other processes, and each operation is followed by trained men who scrutinize each wheel for possible defects in workmanship or material, to the end that a quality product may be insured.

The wheel now finds its way into our industrial life and here begins to render a service to the world. With the development of machining methods has come a development and refinement in machine tools, particularly those classed as precision grinding machines. The precision grinding machine has kept apace with the wheel, until today we have machines and wheels which place the operation of grinding as one of the major machine operations.

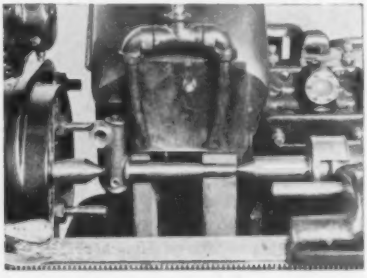
Life has passed through many phases of development. They may be referred to as Ages, that are marked by milestones here and there. Thus we find we have lived through the Stone Age, the Iron Age; we are still living in the Iron Age but this can now be sub-divided so that we may phrase our present day existence as the Machine Age. The Machine Age is now the pedestal on which all civilized life rests. It has overtaken us so rapidly that few can comprehend its trend. Not so long ago it was our problem to produce just enough to meet the demands. Now we have reached a point where the supply easily becomes greater than the demand. Therefore, an artificial demand must be created. People must be induced to desire more and more luxury. This is brought about by first producing goods at attractive prices, and then creating a demand by stimulating a desire of ownership.

Grinding has played an important part in this program. And let us see now just how extensively the grinding wheel and modern grinding machine enter into our daily lives.

Grinding has, perhaps, more than any other operation, made possible the increase in power per unit of weight. So that now we have an aeroplane capable of 1 h.p. per pound of weight.

It influences our daily lives to an extent that many of us do not realize. The bed you sleep in, if of wood, has its parts shaped by ground tools, while if of metal its connecting castings are ground at the foundry. The sheets and pillow cases are spun and woven at faster rates than ever before because grinding has made possible better textile machinery. As you arise in the morning and select your favorite razor for a shave, bear in mind that the keen edge of the razor, the very fine con-

The agricultural industry depends on grinding for equipment.



Automobile Steering Knuckles are produced swiftly and accurately.

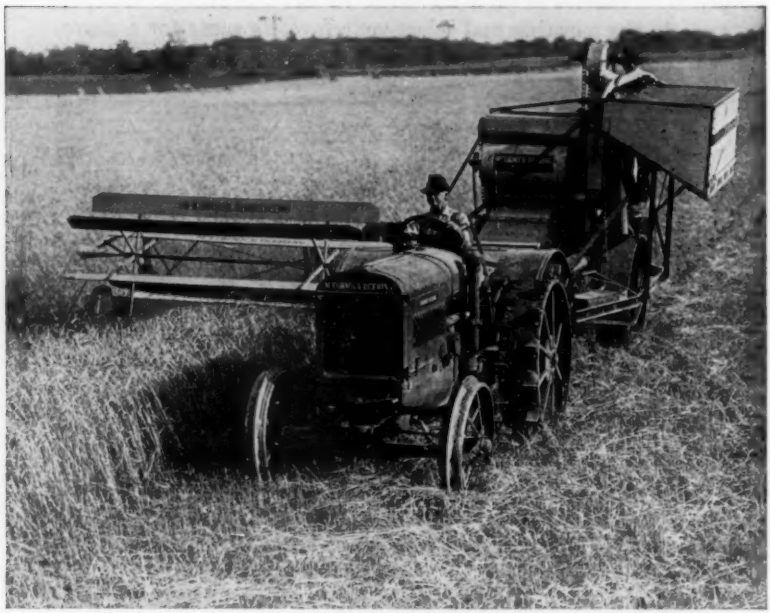
tour of the blade, is only possible by the use of the grinding machine. And the velvety softness of the luxurious shaving cream which softens the beard and makes shaving easy, has been brought about by ground rolls which have been finished to a mirror-like surface with an artificial abrasive wheel.

And now you sit down to the table for your breakfast. Most of the butter you spread upon your toast, and the cream you pour in your coffee, owe their existence to the cream separator whose intricate parts could only be machined by the grinding wheel to the accuracy required. The knife you spread the butter with has been polished and ground. Even the daily newspaper that brings to your breakfast table the news items of the world, is printed efficiently and delivered to you for two cents because of the efficiency of the machines which owe their accuracy to the operation of grinding. Experience has proved as sound as experiment, so that now the pulp of the newspaper

is produced by the grinding wheel instead of the old natural sandstone.

If you should choose shredded wheat or rolled oats for your meal, remember that the modern cylindrical grinding machine is necessary in their production, too. And when you eat your ham and eggs, the ham was sliced by rotary knives that are ground; while the hen that laid the eggs must have cracked corn which must come from a machine having ground parts.

At noon you may have, by way of a reducing diet, only



The Harvester is essential to agriculture on a large scale—Grinding is essential to today's efficient harvester.

spaghetti and cheese, apple pie and milk. The fine flour to make the spaghetti and pie crust is possible only from rolls that are ground. The apple tree is pruned by tools that are ground and perhaps the cow was milked by a machine that has ground parts. At any rate, her fodder was cut and her hay made by machines that employed grinding.

After luncheon you may have an appointment with the dentist. You glance at your watch to find it is nearing the ap-

pointed time. Pause to think! Ground rolls rolled the main spring and the hair spring, and the materials of the case—your watch could not be such an accurate or inexpensive timepiece except for grinding machines When you are under the strain of the dentist chair you are again served by the little grinding wheel that cleans out the cavity, and ground rolls roll the gold with which it is filled

The cotton from which very much of our clothing is made is compressed with hydraulic plungers, which are finished on cylindrical grinding machines. The calico prints of beautiful figures and designs are served by the grinding wheel, for the rolls through which the cloth is passed in the operation of printing or mercerizing, depend upon the grinding machine in the preparation of these artistic designs.

In transportation, and transportation turns of course on rapidly moving parts, grinding wheels are indispensable. Used in automatic machines they shape ball bearings faster than you can count them as they pour out, fashion roller bearings too, and huge parts for locomotive and Pullman car wheels.

The automobile has a part in transportation. By way of illustration bear in mind that in 1904 it took five hours of tedious turning, filing and polishing, to finish the four pins on a Ford crankshaft. Now a far better job is possible by means of the grinding wheels alone in 15 minutes.

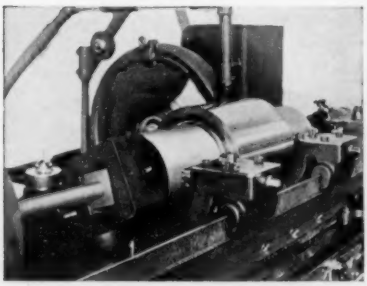
The intricate and accurate shapes on the camshaft of the motor are produced by the grinding wheel, insuring the smoothness of operation and quietness unknown until the machine development made possible the fashioning of this part in this manner. We would not use the automobile so unceremoniously as we do today were it not for grinding. To those who ride on street cars, remember that the sounds coming from the worn treads on wheels could be eliminated if the wheels were ground, insuring greater comfort to the passengers and longer life to the street cars.

Indeed all through the world of metal up and down and all about this universe of tools that are means of our modern civilization, grinding does its share. Here in the steel mill we find a ponderous machine weighing over 100,000 pounds, shaping the huge rolls which transform the steel ingots into useful billets, fashion steel rails and parts for bridges that sometimes support those rails.

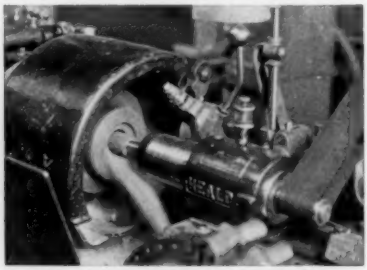
Intricate parts of the linotype machine, huge castings of ditch diggers, the typewriter, adding machine, big guns on the battle-ship, locks of the Panama Canal— all are treated by grinding.

Go with me into the shoe industry, into the forests of the great northwest, the lumber camps, down into the mines of Pennsylvania, the great shipyards, the marble and granite quarries of Vermont, and see a further exemplification of the grinding wheel's importance.

And in agriculture, wherever implements turn or work the soil, wherever tractors operate or reapers gather crops to feed the world, their edges and moving parts are fashioned by grinding.



Highly finished rolls are used in the production of many and varied products.



The inside surfaces of holes are finished to close limits by the internal grinding machine.

We have to go but a step into the realm of our fancy to find that it shapes the teething ring, the first object of usefulness in our start on the pathway of life, and polishes the granite slab which marks our last resting-place. In a word, there is hardly anything that we touch which does not in some way owe its existence to the modern grinding wheel and grinding machine.

There are few industries in which the use of the grinding wheel is not an indispensable part. It sharpens the tools that cut away the mountains and lay the foundations of cities. It polishes the daintiest of the artisan's handiwork, as well as the barrel of the sportsman's fowling piece. It grinds the points on forks and steel pens. It has its part in finishing ornamental glass work, grinding of lenses, and it brings out the brilliancy

of precious stones. Is there little wonder that we mention grinding in its service to the world?

Let us consider some outstanding points in connection with grinding wheel manufacture. The modern grinding wheel is manufactured from artificial abrasives of two distinct kinds—aluminous abrasive made from bauxite and used in the grinding of high tensile strength materials such as steel, and the other, an abrasive material commonly known as carbide of silicon (made from sea-sand, coke and sawdust) is used to grind low tensile strength materials such as cast iron. These two distinct types of artificial abrasives are the modern materials used in the manufacture of grinding wheels. So often have grinding wheels been referred to as emery wheels, it is necessary to make the foregoing explanation. Emery is little, if ever, used in the manufacture of grinding wheels in these modern days of high production.

The bonding material used in the manufacture of grinding wheels also plays a very important part in grinding wheel selection and action. It would take too much time to go into detail as to the resulting action from different kinds of bonding material; suffice to know that wheels are manufactured by various processes, and each process has its specific application. For example: wheels are of the vitrified process, in which the bonding material is clay; they are of the organic process, in which the bonding material may be shellac, bakelite or rubber; they are of the silicate process in which the bonding material is silicate of soda, commonly known as water glass.

Another common belief has been that the part treated will have a finish just as rough as the grinding wheel is coarse, or just as smooth as the grinding wheel is fine. This is not correct. Grinding wheels vary in their grain size in order that we may accomplish certain predetermined results, and the finish of a piece is brought about by correcting the face of the grinding wheel by truing or dressing it, so that this cutting action will produce either a rough or a smooth finish.

A Correction for the *Do You Know* astronomical facts, page 78, January number. 2. Betelguese has a *diameter* nearly 300 times that of our sun. 5. A mass of 160 lbs. on the earth would be about *26 lbs.* on the moon.

Experiment: Comparative Effects of Radiant Energy Upon Land and Water Surfaces

EDITH FOX
Hughes High School, Cincinnati, Ohio

THE following experiment is helpful in proving the statement found in textbooks that the land takes up heat faster than water.

Pour 250 c.c. of water in one beaker and 250 c.c. of dry sand in another. Place these beside each other and hang in each a thermometer so that the bulb of each is just covered. This will test the surface temperature of the sand and water and each will be near 70° F. if they have been in the school room for a short time. To show the way they are warmed by sunlight they must of course *not* be heated from beneath. Place an electric heater with a reflector so that heat is thrown equally on each and take readings every two minutes. Typical results of the experiment:

	11:00 A. M.	11:02	11:04	11:06	11:08	11:10
Sand	70° F.	77° F.	84° F.	91° F.	98° F.	105° F.
Water	70° F.	74° F.	77° F.	81° F.	86° F.	90° F.

The temperature of the sand increased 7° every two minutes and the water an average of 4° F. This experiment is simple enough to be done for 9th grade pupils or even to be done by them and the conclusion is convincing.

United States Leads the World in the Utilization of Its Water-Power Resources

The extent of the industrial development of a nation, which is the modern measure of its civilization can probably be gauged best by the extent of its use of mechanical energy. The total for the United States at the end of 1926 was 11,700,000 horsepower for plants of 100 horsepower or more, as against 13,100,000 horsepower in Europe, presumably for plants of all sizes. In the six-year period 1921 to 1926 the capacity of constructed plants in the United States of 100 horsepower or

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more increased 3,800,000 horsepower, while in Europe the increase in plants of all sizes was 4,200,000 horsepower. During the last three years of that period, however, the rate of increase in the United States was much greater than during the first three years, whereas the rate of increase in Europe showed a decline. The leading countries in Europe in the use of water power and the capacity in horsepower of their constructed plants in 1926 are as follows: Italy, 2,300,000; France, 2,000,000; Norway, 1,900,000; Switzerland, 1,850,000; Sweden, 1,35,000.

The developed water power of Africa amounts to only about 14,000 horsepower, but Japan has built plants aggregating 1,750,000 horsepower, and India 200,000 horsepower. New Zealand has some large plants under construction, but those completed have a capacity of 60,000 horsepower. The Dutch Islands of Java, Sumatra, and Celebes have plants of 80,000 horsepower. Tasmania's plants have a capacity of 75,000 horsepower. Australia depends mostly on fuel plants and has utilized only 2,000 horsepower of its water-power resources.

In South America, Brazil leads the other countries by a wide margin, with 500,000 horsepower, most of it used in Rio de Janeiro and Sao Paulo. Chile's plants amount to 114,000 horsepower, and Peru's to 55,000 horsepower.

Coming back to North America, we find that Mexico has plants with a capacity of 300,000 horsepower. A large part of this capacity is in plants supplying Mexico City and there is not much activity in building new plants. Newfoundland has a large new plant for the manufacture of paper that increases its total to 160,000 horsepower. But the only real competitor of the United States in the whole world is our neighbor Canada, whose plants had a total capacity of 4,556,000 horsepower at the end of 1926, an increase of 2,138,000 horsepower since 1920.

At the end of 1926 the developed water power of the world was as follows: North America, 16,800,000 horsepower; South America, 750,000; Europe, 13,100,000; Asia, 2,100,000; Africa, 14,000; Oceanica, 140,000; total of 33,000,000. As the total capacity of the water-power plants of the world in 1920 was 23,000,000 horsepower, there was an increase of 43 per cent in the six years.

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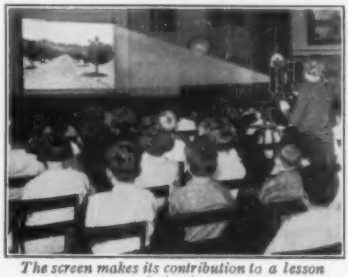

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A Synthesis and Evaluation of Subject Matter Topics in General Science—1929—Francis D. Curtis—83 pages—$1.00—Ginn and Company.

Only a series of painstaking studies and calculations could produce the valuable tables of facts on the subject matter of general science that are given in this book. The final evaluation of topics in percentages gives the science teacher an estimate of the importance of practically every topic which anyone might expect to find in a general science course. It shows that we are approaching, as near as may be desirable, perhaps, a standard general science course. Everyone interested in the teaching of general science should carefully examine the findings of this research study. A foreword is written by Dr. Otis Caldwell.

New Practical Physics—1929—Black and Davis—645 pages—593 illustrations—$1.20—The Macmillan Company.

The reputation of the old edition of having everything worth while, is well sustained in this latest revision. Not only are the fundamentals well taken care of, but the latest developments of physical science are included, as home color-photography, the talking movie, and the dynamic loud-speaker. The text is particularly rich in question and problem exercises. Chapter summaries help to fix the most important facts and principles.

Modern Physics—1929—Charles E. Dull—778 pages—780 illustrations—Henry Holt and Company.

This revision of a successful high school text is very attractive with its abundance of modern applications of science. It is well written and appeals to the student. The illustrations are very good. Besides the usual summary, questions and problems at the chapter ends, a new feature of a vocabulary at the beginning of each chapter is introduced. There is more material in the book than can be covered in one year, but most teachers are glad of an abundance from which to select.

Elements of Physics—1928—A. W. Duff and H. T. Weed—565 pages—463 illustrations—$2.20—Longman, Green and Company.

This is a new book in the high school field. In its 55 chapters it covers the usual topics. The book is written in a pleasing style and is well illustrated. While it covers the fundamentals needed for college entrance, it also has an abundance of practical applications and such new topics as recent aviation data, television and cosmic rays. An excellent feature of the book is the group of questions after each numbered paragraph for the student to see if he really understands what he has been reading. There are the more formal exercises at the end of the chapters.

Elementary Principles of Physics—1925—Fuller, Brownlee and Baker—881 pages—729 illustrations—Allyn, Bacon and Company.

The earlier part of this book is devoted to problems involving simple observations. The subject matter involving abstract and mathematicla treatment is put toward the end. This arrangement is believed, by the authors, to be the natural approach of the student. Curiosity impells a student to ask "What" and "How," but rarely does he progress to the "Why" and "How Much" stage without outside influence. The book has a large number of good demonstrations experiments, plenty of test questions, a summary and chapter-end exercises.

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Introduction to Theoretical Chemistry—1929—C. H. Cartledge—553 pages—71 illustrations—$3.60—Ginn and Company.

This is an outgrowth of the author's earlier college text, "Inorganic Physical Chemistry." It professes to be a text on theoretical chemistry which is "logical from the standpoint of science and approachable from the standpoint of the student." The book is divided into four parts: 1. The Nature of Matter; 2. The Nature of Solutions; 3, The Nature of Reactions; 4. Special Ionic Equilibria.

Our Farm World—1929—Fred T. Ullrich—603 pages—204 illustrations—$4.00—Longmans, Green and Company.

We have not seen a better book on practical science applied to the farm. It is a notable contribution to texts, helpful to the young man or woman preparing to teach in a rural school or to teach agriculture in a town or city school. It is organized on the problem basis and includes material which is of cultural as well as utilitarian value. It gives a chapter to the problem method of teaching, takes up soils and fertilizers, potatoes and corn and their culture, fruits and fruit growing, poultry, dairying, production of beef and pork, sheep, horses and mules. A brief list of general topics covered gives little idea, however, of the excellent treatment they have received in this book. There are exercises, suggested questions, and a good list of references.

College Algebra—1929—Crenshaw and Harkin—234 pages—$1.75—Blakiston's Son and Company.

This text gives a clear and concise statement of the essential fundamental methods of algebra. A large number of illustrative examples are used to show how problems are solved and checked. In many cases alternate methods are included. The chapters are: Fundamental concepts; linear equations; exponents; quadratic equations; ratio and proportion; series; binomial theorem; logarithms; undetermined coefficients; numeral equations; theory of equations; theory of numbers. Answers to problems are given at the end of the book.

Enriched Teaching of Science in the High School—1928—Woodring, Oakes and Brown—385 pages—$2.75—Bureau of Publications, Teachers College, Columbia University, New York City.

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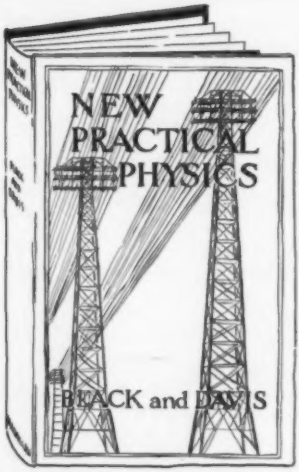

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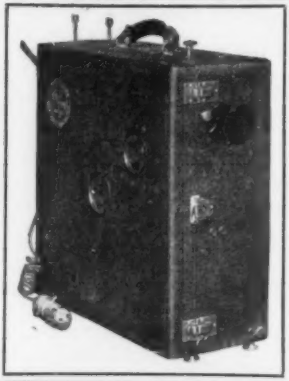

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The Guide to Nature. Sound Beach, Conn. Monthly. 15c a copy, $1.50 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Hygeia. 535 North Dearborn St., Chicago. Monthly. 25c a copy, $3.00 a year. Popular articles on individual and community health. A valuable supplement to classroom work in hygiene.

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Journal of Chemical Education. 85 Beaver Street, New York, N. Y. Monthly. $2.00 a year. Promotes chemical education; primarily a journal for the chemistry teacher. Digests of activities of chemical associations.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $6.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

Journal of Home Economics. 617 Mills Bldg., 700 17th Street N. W., Washington, D. C. Monthly. 25c a copy, $2.50 a year. For teachers.

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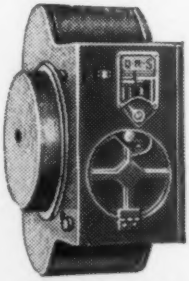

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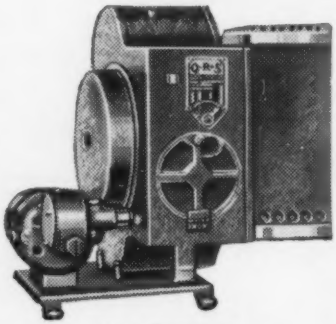

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Science Classroom. Issued by "Popular Science Monthly," October to June. 25c a year. A valuable teacher's aid, giving lesson plans, experiments, and many reference suggestions for secondary science teachers.

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Transactions of the Illuminating Engineering Society. 29 West 39th Street, New York. Monthly. $1.00 a copy, $7.50 a year. Technical. Many articles contain material which can be used in high school classes.